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ABOUT THE CRITERIA FOR EVALUATION OF EFFECTS OF ATMOSPHERIC POLLUTANTS AT LOW CONCENTRATIONS UPON AN ORGANISM

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This reprint of an article by Professor Ryazanov provides background information concerning certain aspects of the Air Quality Standards Program in the Soviet Union.

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About the Criteria for Evaluation of Effects of Atmospheric Pollutants at Low Concentrations Upon an Organism*

The first attempt to develop maximum allowable concentrations of air pollutants has been undertaken by the Soviet hygienists. As a basis for this work the criteria were used which were first published by us in 1949 and which did not meet with any objections in the scientific literature.

These criteria, in essence, are as follows:

1. "An allowable concentration" could be only such concentration of any substance in an ambient air, which does not affect a man directly or indirectly by producing a detremental or unpleasant effect, does not lower his working capacity, and does not affect his mood or sense of well-being.

2. The necessity of acclimatization to the toxic substances should be looked upon as an adverse condition and a proof of untolerable concentration.

3. The "untolerable concentrations" are also such concentrations of toxic substances, which have a damaging effect upon vegetation, climate of a location, visibility or customary conditions of life of the residents.

During the work in regard to the regulation of atmospheric pollution there soon developed examples which indicated insufficiency of the above criteria and of the necessity of their further development and specificity. The first factor that appeared was a question of odors.

There were no doubts in regard to unpleasant odors, since their undesirability in an atmospheric air has been recognized by everyone, but the pleasant odors caused a controversy among the members of the committee engaged in an establishing of maximum allowable concentrations of pollutants. Some members of this committee stated that the pleasant odors bring on a positive emotion in a man and that there is no foundation for forbidding a discharge of such substances by the industry into an atmosphere as long as concentration is below toxic. Otherwise, the hygienists should not allow the growth of flowers in cities, or use of perfumes.

However, there are numerous complaints from the inhabitants of the locations close to installations of the perfume industry. The reasons for the complaints are the compulsory nature of an odor Here we have to deal with an occurrence, which is shared by all irritants: for example, we listen to music over the radio, but we object to the same music when a neighbor forces us to listen to it.

All these served us as a basis for the formulation of the following as a universal hygienic principle: any irritant, pleasant, unpleasant or indiffer-

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ent, becomes unpleasant, unbearable and sometimes pathogenic if it assumes persistent and tenacious character (1954).

It must be remembered that the atmospheric air provides a background for perception of various odors. This background should be neutral, so as not to produce masking of the odors, thus causing an incorrect evaluation of ambient media by olfactory nerves. To allow the presence of pleasant odors in an atmosphere would be analogous to supplying sweetened water by the water system. The inhabitants should be assured of availability of drinking water of a taste desirable at the moment; therefore, it should not have any odd taste.

An analogous situation exists in a field of hygienic control of meteorological conditions. We came to the conclusion that one of the most important general principles of hygienic regulation of ambient media is an assurance of a possibility of modification of it in regard to a man's necessity and desires at any given period of time.

It is fully understandable that the most desirable condition would be one which would permit a regulation of an atmosphere according to taste and desires of each and every individual, and this condition could be satisfied only by an air with complete absence of any odor.

Therefore, during the investigations in regard to hygienic regulation of atmospheric pollution, a special attention has been paid to a threshold of odors. These investigations, however, showed that an absence of odor perception does not indicate that under the influence of an action of unperceived concentration there is no occurrence in an organism of some reflex reactions with the receptors of pulmonary system.

The change in light perception by the visual mechanisms belongs among such reactions. It has been established that some substances are capable of causing changes in light sensitivity even at imperceptible concentrations. F. I. Doobrovskaya proved this for SO_2, M.K. Borisova for dichlorethane, M.M. Plotnikona for acrolein. The later investigations by the other people confirmed an existence of such a reaction for the above compounds, and found it also to be true for a number of other substances as well.

As a rule, the higher concentrations of odoriferous gases cause a decrease in light sensitivity, while the lower concentrations increase it. These changes were interpreted in regard to relationship between nerve centers. When, under an influence of weak odor, a process of excitation takes place in a sensory center it reaches the visual region by way of irradiation over the brain cortex and induces an increase in light sensitivity. If an odor is strong, an excitation which appears in olfactory center, according to a law of negative induction, causes a retardation of the visual region of the cortex and as a result its light sensitivity is reduced.

In our opinion the presence of an air pollutant in concentrations which cause a reduction of light sensitivity, and therefore, a suppression of the functions of visual perception should certainly not be tolerated. It has been more difficult to solve this problem in regard to such concentrations of odoriferous substances which sensitize an excitation in the cortex of cerebral hemispheres, but at the same time are below the threshold of odor perception. It would appear that such concentrations should not be considered harmful, since they do not depress, but stim-

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ulate the activity of visual analysis.

This problem can be solved only on the basis of general hygienic principle, mentioned before, according to which a media should represent a neutral background for development of the activity of an organism. We should have a negative attitude toward the presence of such factors in the ambient media as would induce changes in the functional status of an organism, either decreasing or increasing its activity.

We must allow a possibility of usage of stimulants ranging from cold water and strong coffee to Phenamine, if there is a necessity to increase an excitation and activity of central nervous system, to insure the completion of some pressing project and to remove a feeling of exhaustion. But such usage of stimulants should be completely voluntary and, of course, only on strickly limited, temporary basis.

We should have quite a different attitude toward a compulsory stimulation. It loses its value since it acts simultaneously upon people who require an extra stimulation, as well as those who have completed their work and are in need of rest.

Every hygienist, undoubtedly, would agree that the sleep is the best and the only physiological stimulant. It is a complete rest which gives a restoration of a person's strength and thus stimulates him to highly, effective activity; this is not so for an artificial stimulant, which removes only a sensation of tiredness and exertion. Therefore, in principle, there should not be any form of forceful stimulation, including the irritants of receptive zones of pulmonary organs.

The above considerations gave a basis for a criterion for evaluation of permissibility of one or another concentration of foreign substance in the atmospheric air in regard to not an absence of toxic effects or an odor, but also its sub-sensory characteristics of retarding, as well as stimulating, the organism.

Various methods of study of reflex action of those substances upon a human were tried during the research in regard to hygienic regulation of atmospheric pollution. As it is known, the reflex effects, in particular, upon receptors of pulmonary organs were used as a foundation for establishing of the so-called maximum allowable concentrations of air pollutants over a limited period of time. During this investigation various methods were tried beside an adaptometric, namely, plethysmography, pneumography, optic chronaximetry (F.I. Doobrovskaya, K.A. Booshtooeva, M.T. Tahirov, M K Borisova, M.M. Plotnikova and others). These methods, however, did not offer any advantages over adaptometry. Later, a method of electrocortical conditional reflexes has been introduced which proved to be the most sensitive and convenient of all other methods tried before. Booshtooeva, Polejaeff and Cemenenco (1960) are to be credited with an introduction of this method into a practice of hygienic research.

This method is based upon a desynchronization of λ rhythm under the influence of light sensitization. If a person under observation, were placed into a dark electroencephalographic chamber prior to inducement of light sensitization, and exposed to a test gas at a concentration, which independently does

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not cause desynchronization of α rhythm and within 10 seconds a light sensitization is induced, thus obtaining a joint effect of both the light and an odor, upon a few repeat exposures to such procedure a desynchronization would take place before another light exposure, therefore, a conditional reflex to a odoriferous substance would develop.

It has been discovered that this reflex, which is called electrocortical, develops at a concentration below a threshold of an odor perception and does not affect the light sensitivity of visual analysis This method of disclosure of the irritating action of atmospheric pollutants upon receptors or pulmonary organs has been used in research in regard to establishment of maximum allowable concentrations (Gofmekler, Feldman, Shoolga, Solomin).

Should, however, the modifications of biocurrents of cerebral cortex, which are disclosed by the described method, be interpreted as an evidence that the presence of the test substance, in tested concentrations, would not be tolerated?

The described reactions, in connection with odor and light sensitization, are fully applicable also to a given case. We deal here with an irritation of receptors of pulmonary organs, which causes a development of conditional reflex; i.e., with compulsory stimulation of central nervous system--the fact that we already recognize as intolerable.

It could be said that the reflex processes, studied by us are ephemeral and, therefore, should be disregarded. In reality we deal here with unstable reactions: the sensation of an odor disappears rapidly due to an adaptation, the changes in potentials, stimulation of the cerebral cortex under the influence of inhalation of odoriferous substances, are quickly mullified. Nevertheless, it is well known that the basis for this change of potential is a process of retardation, due to which the effect of the reaction can exist in nerve cells for a long time. In fact, in experiments of Booshtooeva, Polejaeva and Cemenenco, the suppressed reaction on inhalation of SO_2 could be reactivated by an introduction of some other irritant, for an example, a pulsating light. Therefore, the reactions described above, could not be considered as ephemeral.

Everything pointed out above is pertaining to the criteria of evaluation of an effect of atmospheric pollutants, by the way of receptors of the pulmonary system, upon the reflexes. However, it is well known that there exists a general effect, simultaneously with one upon reflexes, which becomes tangible after the study of resorptive action, and which was of great interest since the results were to provide a basis for maximum allowable--an average of 24 hours--concentrations of atmospheric pollutants. The chronic experiments upon small laboratory animals were used for this purpose; the animals were kept in chambers with known concentrations of the substance under investigation The following tests were used: measurements of changes which occurred in conditional reflex activity; the relationship of chronaxy of ligaments of antagonists; an excretion of coproporphyrin in the urine, activity of albumin fraction of blood; histological structure of internal organs, particularly axodendral and axosomatic central neuronal connections; behavior and the weight of the animals, etc. Great attention has been paid to an accumulation of toxic substances in the animals organs.

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As it is known, the unwholesome factors in the ambient air do not cause a pathology in an organism immediately. Considerably earlier, i.e., at lower concentrations and the shorter exposures they stimulate various protective reactions. Such reactions are not pathologic yet, and disappear quickly after the termination of an action of the noxious factor. Some people thought that an appearance of protective reactions could not be considered as a criterion for judging such concentrations as intolerable and that only an evidence of pathological changes in an organism may be used as a criterion. We consider such position incorrect and objected to it very decidely as early as XIII Soviet Nationwide Convention of Hygienists. From one point of view, a mobilization of protective mechanisms indicates that the composition of an atmosphere has deviated from its optimum. Therefore, this mobilization of protective sources should be considered as a direct evidence of the unfitness of a medium as a hygienic optimum.

Let us give some examples. Gradually increasing indications of changes in a region of artificially induced stereotypical conditioned reflexes have been discovered upon a chronic action of very low concentrations of benzene, which do not yet cause any changes in a blood production. These changes appear in a form of development of a phase retardation with a subsequent loss of certain positive conditional reflexes. These symptoms disappear during a short recovery period of 1 - 2 weeks, being replaced by a normal picture of high activity of nerves. (Y.V. Novikoff)

It is self explanatory that we do not deal yet with pathology. Here, most likely, we meet with an initial form of protective retardation. A hygienist is obligated, however, to interpret these manifestations as an indication of deviation from the optimum conditions, i e., as an evidence of the damaging nature of the substance present in such concentrations.

During a study of the effect of chronic exposures to very small concentrations of damaging substances, it has been found that in a number of cases an upset of normal relationship between a chronaxy of ligaments of flexion and extension took place. (Chjao - Chjen - Cze, Duan - Phen - jooe; Y. G. Fel'dman, V.A. Gofmekler and others). As long as the normal relationship of chronaxy of ligaments of antagonists is viewed as a result of subordinated effects, an upset of this relationship must be interpreted as a process of retardation in a brain, which in itself indicates a raise of protective processes and evidently a deviation of an atmosphere from optimum conditions.

During chronic lead poisoning an accumulation of it in various organs and particularly in bones takes place. A study of this process at various concentrations of lead (M.I. Gooseff) shows that the lead deposits in bones are found only when the concentration of it is ambient air reaches approximately one microgram per cubic meter. At lower concentrations, however, and amount of lead, introduced into an organism is balanced against that which is excreted. The majority of specialists believe, that an accumulation of lead in bones cannot be looked upon as pathology. It might be thought, however, as that the deposition of lead in bones is a protective - acclimatization reaction; an organism, not being able to excrete a sufficient amount of lead eliminates it from blood stream by immobilizing it in bones. As long as we have seen above, that protective reactions manifest a deviation of an atmosphere from an optimum, we must evaluate the lead concentrations of such magnitude as one microgram per cubic meter and higher as intolerable in ambient air.

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The above examples show, that in interpretation of changes, which take place in human organism or that of an experimental animal, we were compelled to accept different and stricter criteria, than it is done in a field of industrial toxicology. This is, however, quite natural. From the very start of the work in regard to establishing of maximum allowable concentrations it has been obvious to us that these concentrations should be considerably lower than those permitted by industry. Under industrial conditions a worker inhales pollutants during 6 - 7 hours, while the population inhales the polluted air for 24 hours. In the first case we deal with adults in fair health of an age most capable for work, the most resistant to adverse conditions, while in the second case, we deal with aged, the sick, children, i.e., the contingents to reduced resistance to toxic substances.

Furthermore, when the industrial hygienists establish maximum allowable concentrations of noxious substances in an air of the shops, they expect the workers to spend their 17 - 18 hours of rest in a clean atmosphere beneficial to processes of restoration. Therefore, the social hygiene should demand an optimum condition from an ambient air for the entire population.

We do not want, of course, to insist that the maximum allowable concentrations of atmospheric pollutants, established in U.S.S.R. are final. Quite the contrary, as experience has shown that there have been some errors, which had to be corrected on the basis of further scientific research. Therefore, the maximum allowable concentrations should be constantly improved and reviewed as the new scientific data becomes available. It is also necessary to improve the methods and the criteria for their establishment. However, this is the usual mode of learning: an absolute truth is learned by us only by the way of gradual approximation to it through relative truths.

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